VARIATION IN LITHOBIUS FORFICATUS.

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As long ago as 1865, Dr. H. C. Wood in his "Myriapoda of North America" called attention to the great variation in that group and tabulated many variations. I have chosen *Lithobius forficatus*, the most common of the Chilopoda in the eastern part of our country, for a quantitative variation study.

Lithobius forficatus is a cosmopolitan species, found in Europe as well as America. This paper will furnish a place-mode for the species at Cold Spring Harbor, Long Island. Comparisons with place-modes from distant locations will be instructive. Since the variations found are in specific characters such as prosternal teeth, coxal pores, antennal joints and spines we might hope for suggestions as to whether selection in Lithobius is tending in any definite direction? Are the polygons skew in any special way? Is *Lithobius forficatus* a stable or unstable species? Any satisfactory answer to such questions would help our knowledge of the method of origin of species, and in so far advance this, the chief aim of modern biology.

Cold Spring Harbor has a moist climate with abundance of vegetation, a corresponding wealth of insect life and, correlated with these conditions, an abundance of the carnivorous Lithobius. The prevailing species is *L. forficatus*, although in looking over my material I find three specimens of *L. multidentatus* which must have been taken at Cold Spring Harbor. Myriapods of other genera are also common, *Scolopocryptops sexspinosus* and a Geophilus, probably *G. mordax*, represent the Chilopods and Polydesmus, Polyxenus, and some of the Iulidæ the Chilognaths.

The animals were collected during the summers of 1899 and 1900. The greater portion came about equally from a "trap" of mowed yard grass on the upland 300 feet above tide level and from a shaded moist region down within a few feet of highest tide. Here some logs and planks served as traps. The Litho-

bius breed in this latter location, since great numbers of very small white individuals 3 to 8 mm. long are to be found in the hiding places during the months of July and August.

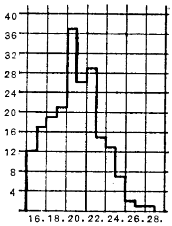


FIG. 1. The length polygon of 200 individuals.

I took the length of 200 individuals, 100 males and 100 females (Fig. 1). The length was measured from the head between the bases of the antennæ to the end of the anal segment — not to the ends of the posterior legs. The polygons were also drawn for the 100 males alone (Fig. 2), for the 100 females (Fig. 3), and for 100 mixed specimens, 51 males and 49 females, which had been selected entirely at random and so with no regard to sex (Fig. 4). On this last 100 all the other determinations were made. The complete data from this last lot are given in Table 9.

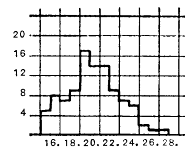


FIG. 2. Length polygon of 100 males.

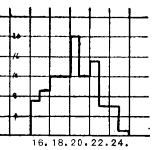


FIG. 3. Length polygon of 100 females.

Because Lithobius grows by moults, only those specimens 16 mm. long or more were measured in order to have a somewhat homogeneous group. They are probably all adults or nearly so. The longest male was 28 mm. long and the longest female was 25 mm. long. There are two apices for the length polygon, the greatest number of individuals (37) falling in the 20 mm. class and the next greatest (29) in the median class, 22 mm. It would take but three individuals to level up the depression at 21 mm. so that the polygon might be considered unimodal. It is skew to the right, due to the rejection of the smaller, younger individuals which would have fallen to the left side of the polygon. The same two classes are the modal classes in the mixed polygon. (Fig. 4) and the polygon for the 100 females, (Fig. 3). The polygon for the 100 males (Fig. 2,) has but one mode at 20 mm.

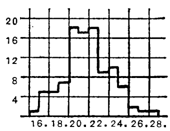


FIG. 4. Length polygon of 100 specimens, 151 males and 49 females.

TABLE 1.

Length in mm.	16	17	18	19	20	21	22	23	24	25	26	27	28
200 indiv.	12	17	19	21	37	26	29	15	13	7	2	1	1
100 males	5	8	7	9	17	14	14	9	7	6	2	1	1
100 females	7	9	12	12	20	12	15	6	6	1			
100 mixed	1	5	5	7	18	17	18	9	10	6	2	1	1

These data are represented graphically in Figs. 1 to 4.

TABLE 2.

Length Polygons	Type	Mean. P. E. M.	St. Dev. P. E. St. Dev.	Coef. Var.
200 indiv.	1	20 43 $\pm$ .12	2.446 $\pm$ .083	11.97
100 males	4	20.87 $\pm$ .15	2.29 $\pm$ .11	10.97
100 females	1	19.96 $\pm$ .15	2.245 $\pm$ .107	11.25
100 mixed	1	21.41 $\pm$ .15	2.35 $\pm$ .11	10.99

For the 100 mixed individuals, 49 females and 51 males, counts were made of :

1. The number of prosternal teeth.
2. The number of joints in the antennæ.
3. The number of coxal glands, pits or pores which are found on the coxæ of the last four pairs of legs (the 12th, 13th, 14th, and 15th). These data are given in their entirety in Appendix A.

According to the key for the different species of Lithobius in Bollman's "Myriapods of North America" the number and arrangement of the coxal pores, the spines on the legs, the number of joints of the antennæ and the prolongations of the posterior angles of certain of the dorsal plates are the decisive specific characters. I append an abbreviated key taken from Bollman ('87) for the two species *L. forficatus* and *L. multidentatus*. I intended to include in the data counts of the ocelli also but it was impossible. As Bollman says "the ocelli are distinct or not" and in many cases the fusion was nearly as complete as in Scutigera where there is a close approach to the facetted compound eye.

Posterior angles of the 9th, 11th and 13th dorsal plates produced. Anal feet with a single spine, the penultimate with two. Coxæ unarmed. Coxal pores in a single series. Antennæ more than 30 jointed. Claw of the

female genitalia tripartite. Coxal pores transverse, on 12th coxæ 6–9, on 13th 6–10, on 14th 6–9, on 15th (anal pair) 4–6 pores. Joints of antennæ 33–43. Prosternal teeth 8–12 . . . . *Lithobius forficatus*.

(Coxal pores round in younger specimens.)

Posterior angles of the 6th, 7th, 9th, 11th, and 13th dorsal plates produced. Anal feet with a single spine. Coxæ armed. Coxal pores multiseriate. Joints of antennæ 19–23. Prosternal teeth 14–18. Coxal pores arranged in 3 to 5 series. . . . . *Lithobius multidentatus*

(Specimens 12 mm. long have coxal pores in 2–3 series, those 10 mm. long in 1–2 series and those 5 mm. long have round pores in a single series.)

PROSTERNAL TEETH.

TABLE 4.

Number of teeth	8	9	10	11	12	13	14
Number of individuals	4	4	40	18	25	5	4

This distribution is represented graphically in Figure 5.

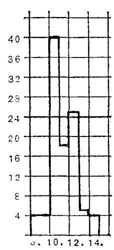


FIG. 5. Polygon of the prosternal teeth shown in Table 4.

The tendency to bilateral symmetry here in the number of teeth is very strong and so gives a bimodal curve with apices at 10 and at 12. But at the ends of the series the bilateral tendency is overcome by the tendency to adhere to the more typical numbers. The tendency to variation, even though it be towards bilaterality, is not so strong as the adherence to the more usual number. There are more individuals with 13 prosternal teeth than with 14 and as many with 9 as with 8.

Figure 6 shows the ventral side of the head of a specimen of *L. multidentatus* with fewer prosternal teeth than *L. forficatus* (Figure 7) has. The number of prosternal teeth is not a good specific criterion as they overlap a great deal in the two species.

JOINTS OF ANTENNÆ.

TABLE 5.

No. joints.	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
Right	1	2	2	4	6	6	13	15	12	8	8	8	2	1	0	0	1
Left	3	1	3	2	6	15	9	15	12	8	6	6	1	2	0	0	0

There were 89 individuals possessing antennæ (either one or both) with as many as 34 joints. This minimum was chosen arbitrarily because in Bollman's key *L. forficatus* is said to have

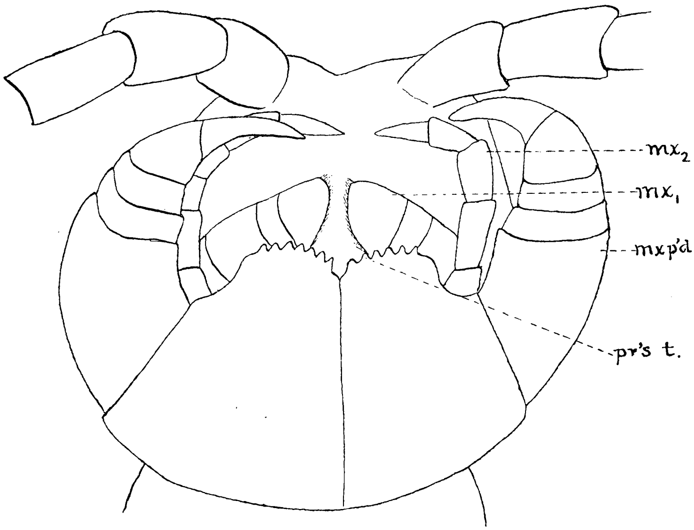


FIG. 6. Ventral view of the head of *L. multidentatus*. × 17.

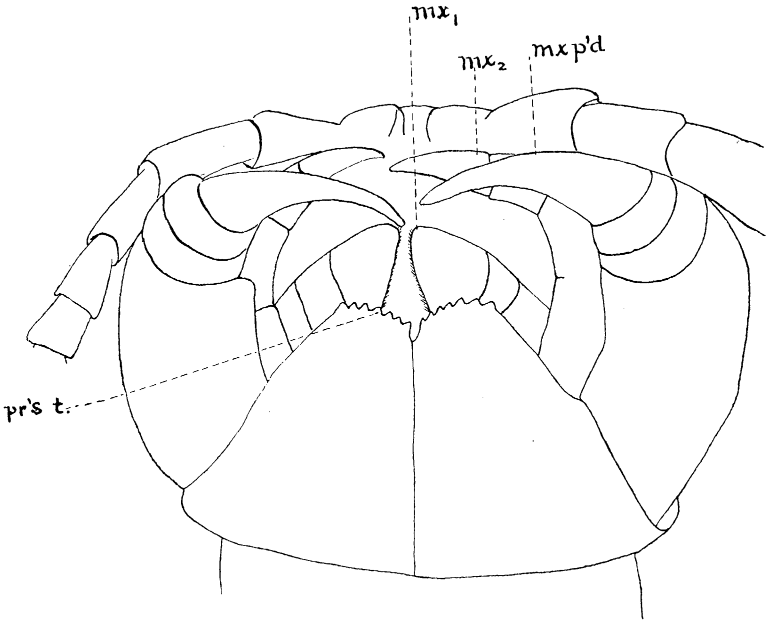


FIG. 7. Ventral view of the head of *L. forficatus*. × 17.

33–43 joints in the antennæ. In the table of data (Table 9) it is shown by underlining that two of the right antennæ counted ended abruptly (Numbers 8 and 50). On the left 33, 50, 57 and 86 had broken ends. The presence of a rounded tip does not necessarily indicate perfectness but possibly merely that regeneration took place at the last moult. Since the antennæ are so liable to injury not much stress can be laid on the polygons (Fig. 8), derived from them. The mode lies at 41 in the right with an average of 41.23. There are equal numbers in classes 39 and 41 on the left side and the average is 40.77.

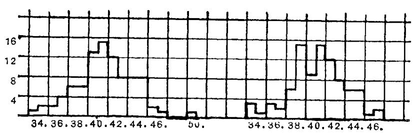


FIG. 8. Polygons of the antennæ, Right and Left.

The number of joints in the antennæ make a good "quick" distinction between *L. forficatus* and *L. multidentatus*. The latter has fewer joints (about as 21 to 43) but the individual joints are longer. This can be seen on the left side of Figures 6 and 7.

COXAL PORES.

In the very young individual the hinder pairs of legs are not yet budded out. The 13th, 14th, and 15th pairs of legs grow in rapid succession, they may possibly all be indicated at the same moult. This increase in the number of legs takes place when the animal is less than 10 mm. long.[1] The 12th pair of legs is the first pair to bear the pits on the coxæ so that these are the oldest pits of the series ontogenetically. The youngest specimens that showed coxal pores at all had two pores, one on each 12th coxa. These were round. They must of course increase in number at the times of moulting until the adult condition is reached. For the condition of the coxal pores in the three hinder pairs of legs in both species under consideration, see Figs. 9 and 10.[2]

[1] Specimens of Lithobius of about this length are often violet in color while those shorter are always white.

[2] Because of the magnification necessary to bring out the pores and the consequent reduced size of field, the 12th pair of coxæ could not be included.

What is the function of these pits on the four posterior pairs of coxæ? Coxal pores are found on many arthropods and are considered to be homologous either with the setigerous glands or with the nephridial openings of Chætopods. In Peripatus, according to Sedgwick ('95) page 19, a series of pairs of glands lie in lateral compartments of the body cavity with ducts opening on the lower surface of the legs. Peripatus has no malpighian tubules but has nephridia like those of the Annulata, which also open at the base of the legs. The slime glands at the base of the oral papillæ may be coxal glands modified for defence. Closed coxal glands occur in adult scorpions, scorpion spiders and many spiders. They are found at the base of one or more pairs of legs. In recently hatched individuals the duct can be traced to the exterior. These animals all possess one or more pairs of malpighian tubules. The "brick-red" gland found in Limulus, whose duct in the

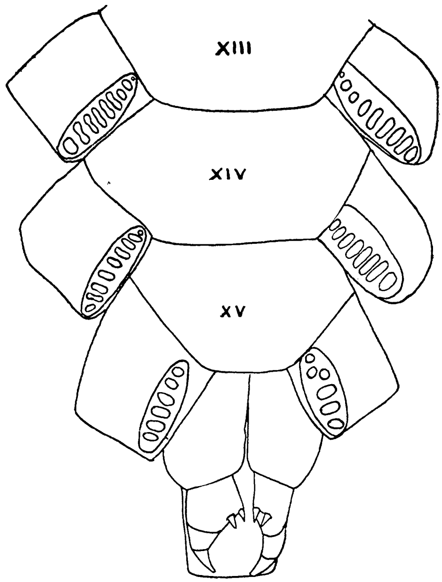


FIG. 9. Ventral view of the last three segments of *L. forficatus* showing coxal pores and female genitalia. × 17.

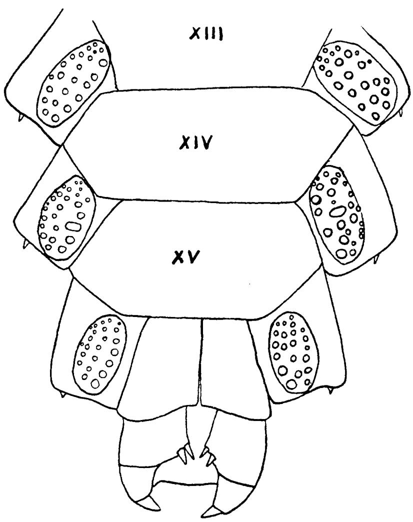


FIG. 10. Ventral view of the last three segments of *L. multidentatus*. × 17.

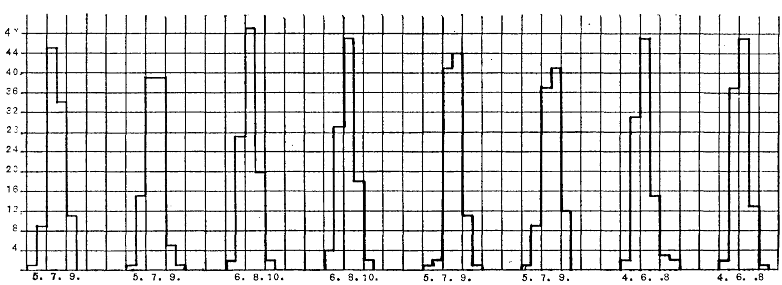
adult was demonstrated by R. W. Tower ('95, page 471), may correspond to these glands and if it does they are certainly renal in function.

Lithobius possesses malpighian tubules and sections have not demonstrated any connection or passage-way from these coxal glands to the body-cavity. The cup-like depression is lined with columnar gland cells which appear to be in condition to secrete actively. The glands may be secondary characters connected with reproduction for they increase rapidly in number up to adult life and then remain in a condition of comparative equilibrium. There is also the possibility that they secrete a recognition substance.

The number of pores is certainly very variable, as only 19 out of the 100 examined had them arranged in a bilaterally symmetrical fashion.

TABLE 6.

Number of pores	4	5	6	7	8	9	10
12th leg left	–	1	9	45	34	11	–
12th leg right	–	1	15	39	39	5	1
13th leg left	–	–	2	27	49	20	2
13th leg right	–		4	29	47	18	2
14th leg left	–	1	2	41	44	11	1
14th leg right	–	1	9	37	41	12	–
15th leg left	2	31	47	15	3	2	–
15th leg right	2	37	47	13	11	—	—



12th leg left. 12th leg right. 13th leg left. 13th leg right. 14th leg left. 14th leg right. 15th (anal) leg left. 15th leg right.

FIG. 11. Polygons of the coxal pores on the 12th–15th pairs of legs of *L. forficatus*.

These distributions of frequencies are illustrated graphically in Figure 11.

TABLE 7.

Coxal pores	Type	Mean. P. E.	Fact. Skew.	St. Dev. P. E.	Coef. Var.
12th leg left	1	7.45 ± .057	+ .004—	.84 ± .04	11.29
12th leg right	4	7.35 ± .058	+ .002—	.865 ± .041	11.7
13th leg left	1	7.93 ± .053	+ .07	.79 ± .038	10.56
13th leg right	1	7.85 ± .056	+ .037	.829 ± .04	9.9
14th leg left	4	7.65 ± .053	— .058	.78 ± .037	11.88
14th leg right	1	7.54 ± .057	— .132	.85 ± .04	11.3
15th leg left	1	5.92 ± .962	+ .49	.91 ± .043	15.4
15th leg right	1	5.74 ± .05	+ .188	.74 ± .935	12.94

What the significance of the fact that the average number of pores is greater on the left side than on the right is I have been unable to determine. The factor of skewness of the left curves also tends to be more to the right even where (14th leg) the curve is skew to the left. There is a similar instance recorded by Bateson, ('94, p. 283), where the abnormality in the number of nipples in the human is higher on the left side than on the right.

Correlations.

TABLE 8.

I. *Coxal pores of the legs correlated.*

Coeff. Corr. or ρ	P. E. Coeff. Corr. or P. E.	
Anal pair legs	.575	± .039
14th pair legs	.69	± .021
13th pair legs	.686	± .029
12th pair legs	.58	± .039

II. *Coxal pores of different legs correlated.*

Anal R. & 12th L.	.427	± .046
Anal R. & 14th R.	.44	± .05
14th R. & 13th R.	.722	± .027
14th L. & 13th L.	.693	± .023
13th R. & 12th R.	.464	± .048

III. *Length correlated with different characters.*

a.	With cox. pores			
		Anal leg R.	.227	± .062
		14th leg R.	.308	± .059
		13th leg R.	.298	± .059
		12th leg R.	.205	± .063
b.	With number of joints in antennae		—.013	± .067
c.	With number of prosternal teeth		.131	± .066

CONCLUSIONS.

1. From the latter part of Table 8 it will be seen that length has little to do with the number of joints in the antennæ. If the — sign were significant it would mean an inverse correlation, the longer the animal the fewer antennal joints. But the probable error is ± .067 so that ρ may as likely as not lie anywhere from —.08 to + .054. There is thus essentially no correlation. You can say, a priori, that the antennæ of the larger, presumably older specimens are more likely to have been broken and to be found regenerating. There is no way of telling a regenerated terminal segment from an original termination.

2. Length of body and number of prosternal teeth have little to do with each other, the coefficient of correlation varying between .065 and .195. I picked out from the data the four individuals with 14 prosternal teeth, the maximum number. Their lengths were 24, 24, 22, and 21 mm. In the four individuals with 8 teeth, the minimum number measured, the lengths were 20, 22, 23 and 23 mm. This tells roughly what the coefficient of correlation tells precisely. In the case of the curve for the prosternal teeth, which is strongly bimodal, the bimodality is due to the tendency towards bilateral symmetry. At the ends of the series this tendency is overcome by the tendency of variations to revert toward or group around the mode. Hence the larger number of individuals with 9 and 13 teeth compared to those with 8 and 14 teeth.

3. The length bears a more decided relation to the number of coxal pores. The number of coxal pores on each of the right legs was correlated in succession with the length. The coeffi-

cients of correlation of the pores of the right side were, according to Table 8: Anal, .227; 14th, .308; 13th, .298 and 12th, .205. That is, the anal and 12th leg coxal pores are more independent of the length of the animal than are those of the 13th and 14th legs. In other words the correlation is less at the ends of a linear series. I had expected the anal pores, the youngest ontogenetically, to vary quite closely with the length of the animal, the fewer pores on the shorter animal and vice-versa. This is found to be true if a group of shorter animals, 6–15 mm. in length be measured. The coefficient of correlation of the pores of the right anal legs with the lengths in a group of 49 young individuals is .88.

4. In the first part of Table 8 are correlated the coxal pores of the pairs of legs, right with left. Here again the correlation is smaller at the ends of the series. The correlation is much closer than it was with the length but the pores of the anal pair have a coefficient of .575 and the 12th of .58 against .686 for the 13th and .69 for the 14th. The order is the same as in the length correlations except that now it is the anal pair of legs which shows the least correlation whereas it was the 12th which corresponded least closely to the length.

I tried also one pair of diagonal cross correlations and some serial correlations with very interesting results. The coefficient of correlation of the coxal pores of the right anal legs and the pores of the 12th legs is .43. That of the anal pores R. with the 12th pores R. is .44. Consequently, diagonal correlation of the ends of the series is nearly as close as the correlation of the terminal members of the series on one side of the animal.

Calculating the correlation of the pores of each leg with the one next it on the right side of the animal there is shown again the difference in closeness of correlation between the ends and the middle of the series. But the closeness of correlation of the 14th R. pores with those of the 13th R. (.722) was so high that I tried the opposite side, the 14th L. with the 13th L. and found not quite as close a relationship but yet one higher than any previous correlation obtained. There is here an unusual case. In a bilaterally symmetrical animal the relation existing between two adjacent segmentally arranged groups of

organs is greater than that existing between the two symmetrical groups of one segment. That is, *the morphological kinship between successive segments is greater than the likeness between the two sides of a segment.*

In trying to trace the ancestral history of any species, resemblances which point toward a related species are valuable. We have these in *Lithobius forficatus* and *L. multidentatus*. The drawings of the two types of coxal pores, Figures 9 and 10, show how the normal condition in *L. forficatus* can be suggested by variations in *L. multidentatus* and *vice versa*. We know that the first condition of the pores in both species is the same, a single row of small round pores. This is probably the ancestral condition. A fusion of two pore rudiments in *L. multidentatus* would give the oblong shape natural in *L. forficatus* and to be seen twice in the drawing of *L. multidentatus*. On the other hand a further constriction of the middle of the long narrow pores of *L. forficatus* (left hand upper coxa) would result in a two rowed condition. How the many rowed condition arises from the single row in L. multidentatus and the phylogeny of coxal pore patterns in general is a subject for further study. That abnormalities in one species may indicate the normal condition in a related species has been shown by Davenport ('00).

SUMMARY.

1. A place-mode is furnished for *Lithobius forficatus*, for the years 1899 and 1900, at Cold Spring Harbor, Long Island.
2. Length of body has essentially nothing to do with the number of antennal joints in specimens 15 mm. long or more.
3. Length has very little to do with the number of prosternal teeth.
4. Length has some bearing on the number of coxal pores in the adult, the correlation being closer on the 13th and 14th legs than on the 12th or 15th legs.
5. Coxal pores show a greater segmental or serial correlation in the case of the 13th and 14th legs than bilateral symmetry.
6. Variations in the one species of Lithobius point toward the normal condition in the other species under consideration.

In conclusion I wish to express my thanks to Dr. C. B. Davenport for his many kindnesses in directing the work and for criticising the paper.

LITERATURE CITED.

1. BATESON.
   '94. Materials for the Study of Variation.
2. BOLLMAN, C. H.
   '93. Myriapoda of North America. Edited by L. M. Underwood. *Bull. U. S. National Museum.* No. 46.
3. DAVENPORT, C. B.
   '99. Statistical Methods.
4. ——
   '00. On the Variation of the Statoblasts of Pectinatella. *Am. Nat.* Vol. 34, No. 408.
5. SEDGEWICK, A.
   '95. Peripatus. *Camb. Nat. Hist.* Vol. 5.
6. TOWER, R. W.
   '95. The external opening of the "Brick-red" gland in Limulus. *Zool. Anzeiger* Dec. 1, p. 471.
7. WOOD, H. C., Jr.
   '65. On the Myriapoda of North America. *Trans. Am. Phil. Society* Vol. 13 N. S. Part 2. 137–248. 3 Pls.